3DST Software

Preliminary Full Spill Studies w/ ECal

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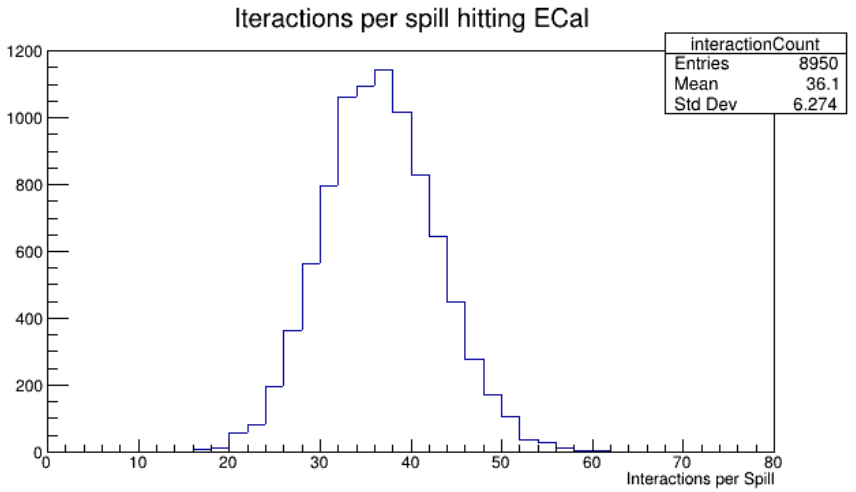
- The full spill simulation
  - ECal simulation is approximate
  - These are ECal, 3DST & TPC centered
    - result probably applies to ECal & STT as well.
  - Both RHC and FHC studied
- Basic performance with different ECal integration times
  - Looked at 30 ns and 400 ns
  - Has a direct impact on beam monitoring signal and backgrounds
  - This doesn't determine selection efficiency and backgrounds
    - Need studies from ECal experts

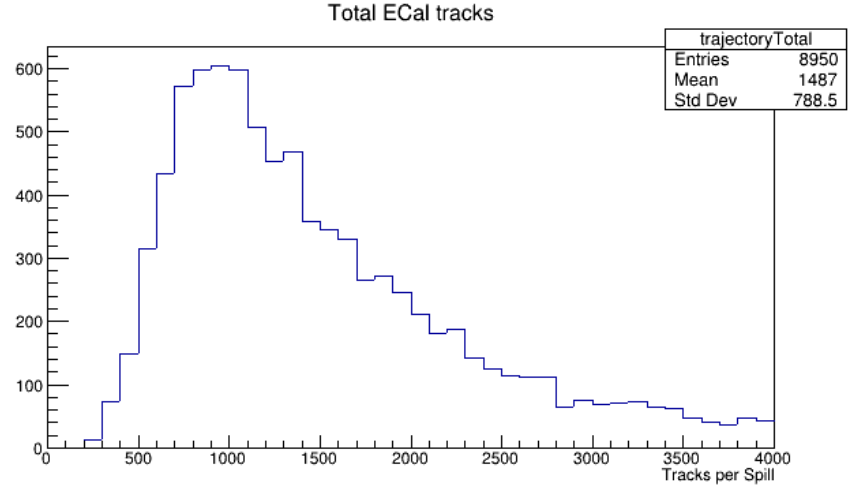
The Full Spill Simulation

- Use the full chain
  - GENIE:
    - FHC and RHC beam with 7.5×10^{13} POT per spill
    - Includes 250 m of rock upstream of hall
  - EDepSim:
    - Track all particles, but only save trajectories hitting sensitve detectors
  - sand-stt:
    - Simulate ecal response for each individual interaction
  - ERepSim:
    - Overlay interactions (~3500 per RHC spill).
    - Simulate 3DST and TPC
      - Overlay edep-sim results and simulate electronics response
    - Use sand-stt for ECal
      - Uses 400 ns integration, and does not include dead time and event overlap.
      - For each channel, sort hits by time, and combine hits within the targeted integration window (either 400ns or 30 ns).
  - CubeRecon
    - Already built to handle full spill, so just run it.

RHC interactions hitting the ECal

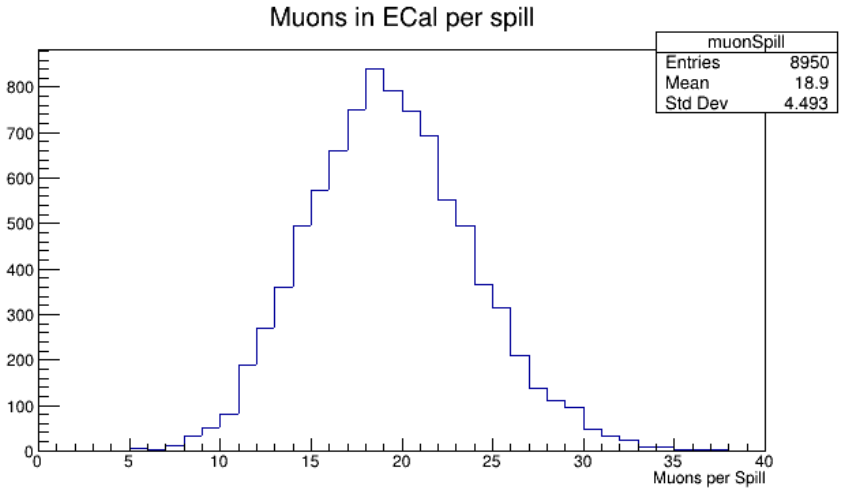
- An interaction hits the ECal if:
  - A charged particle deposits energy
  - Deposited energy generates enough light
- Interactions per RHC spill: 36.1
  - Most of the interactions are from the upstream side of the yoke
- Generated Tracks
  - Create a hit above threshold
  - Effect of overlaps not considered
- Generated Tracks per spill: 1487
  - Lots of small hits just above threshold

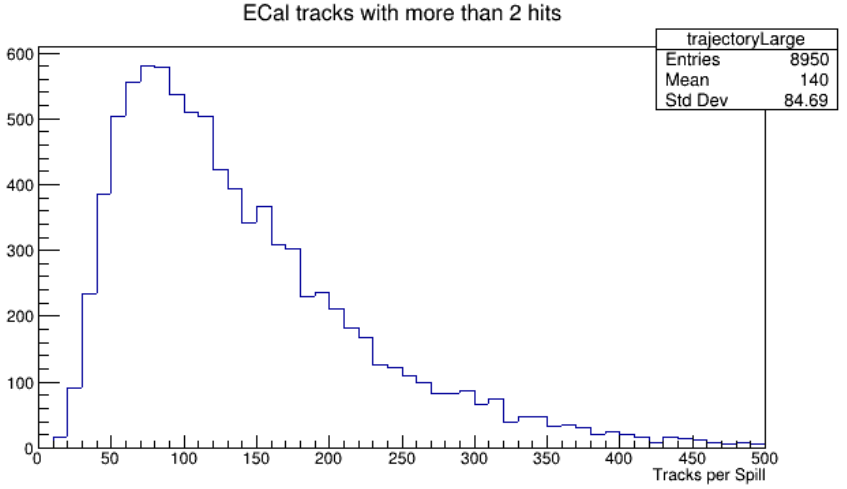




Resulting Particles per RHC Spill

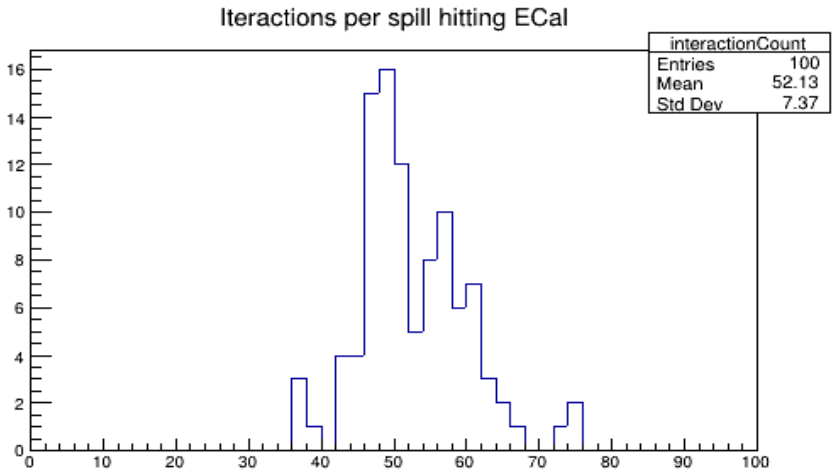
- Looking at particles that "should" make a cluster
- Muons: 19 per spill
  - These are muons that hit any part of the ECal
  - Muon entering upstream side
    - 15.1 per spill
- Tracks: 140 per spill
  - These are all tracks that generate hits in three or more cells

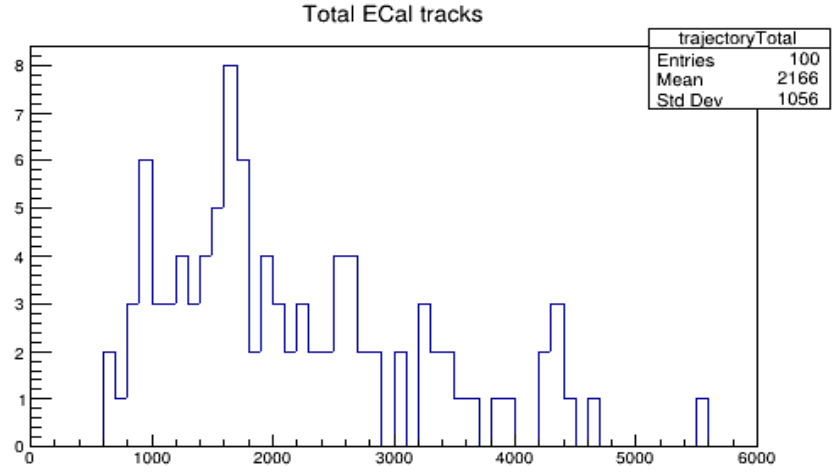




FHC interactions hitting the ECal

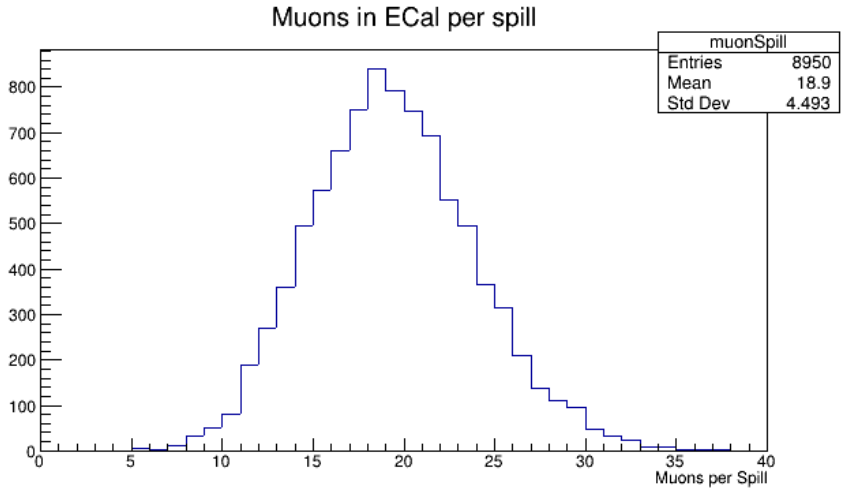
- An interaction hits the ECal if:
  - A charged particle deposits energy
  - Deposited energy generates enough light
- Interactions per FHC spill: 52
  - Most of the interactions are from the upstream side of the yoke
- Generated Tracks
  - Create a hit above threshold
  - Effect of overlaps not considered
- Generated Tracks per spill: 2166
  - Lots of small hits just above threshold

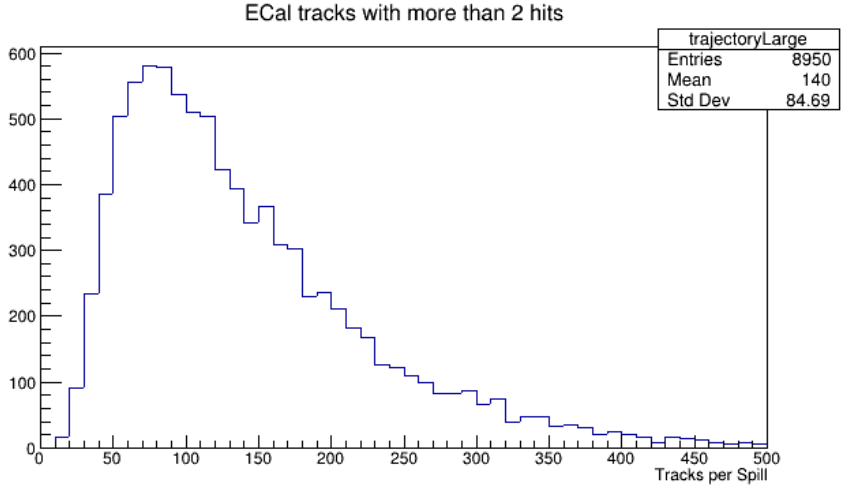




Resulting Particles per FHC Spill

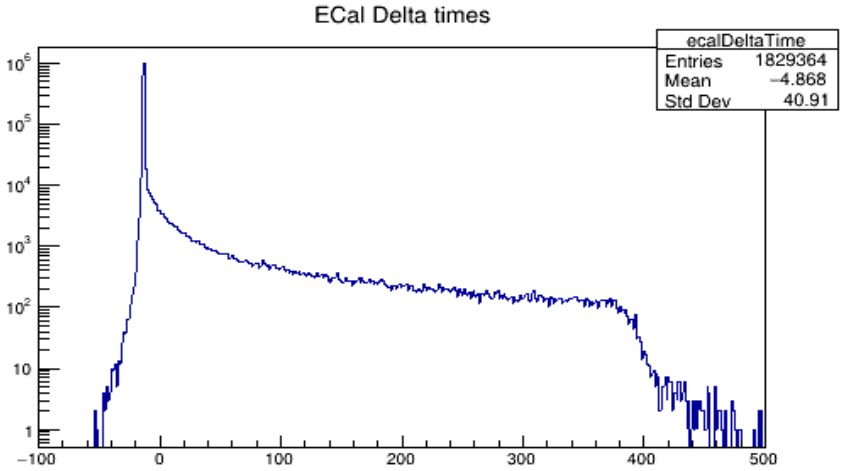
- Looking at particles that "should" make a cluster
- Muons: 31 per spill
  - These are muons that hit any part of the ECal
  - Muon entering upstream side
    - 24.4 per spill
- Tracks: 188 per spill
  - These are all tracks that generate hits in three or more cells

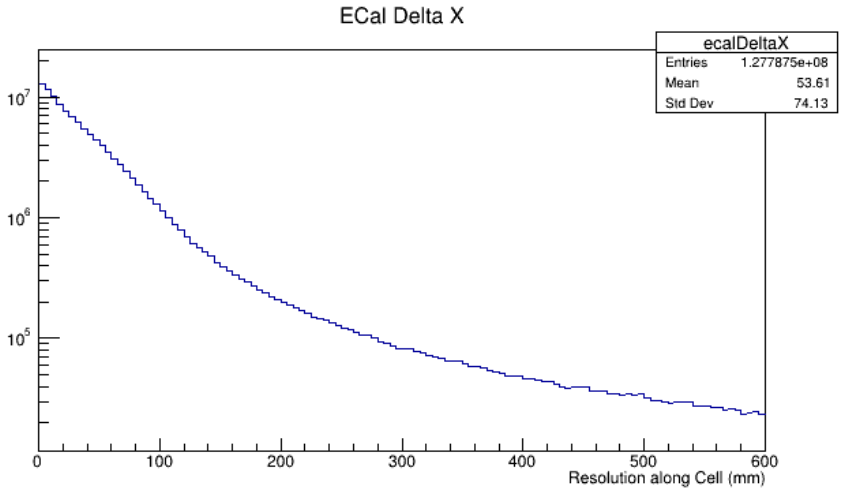




ECal Cell Time and Position in Spills

- Double ended read-out means the time and position
  - These plots are for the 400 ns integration window
  - Reco Time is the average distance corrected time for both ends of the cell
- Undershoot caused by geometric effects (tracks closer to sensors)
- Position is from the time difference between the ends of the cell
- Similar for FHC and RHC
  - Plots are for FHC
  - Strongly affected by ECal thresholds (not well simulated)



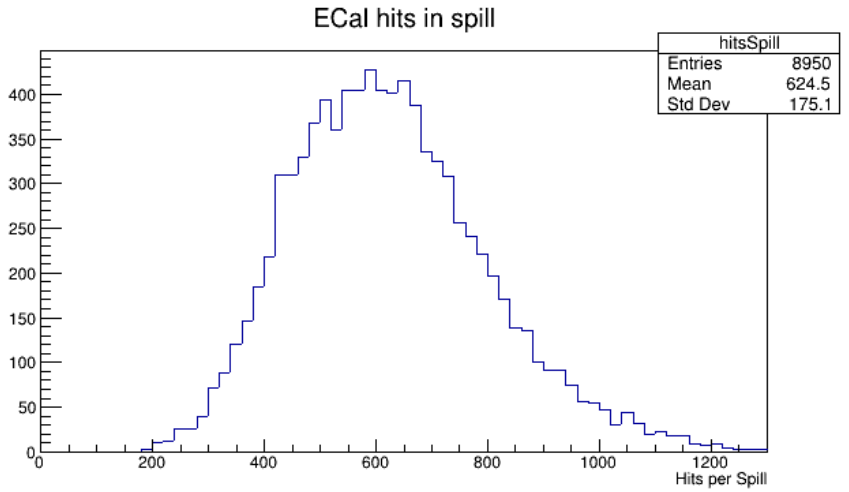


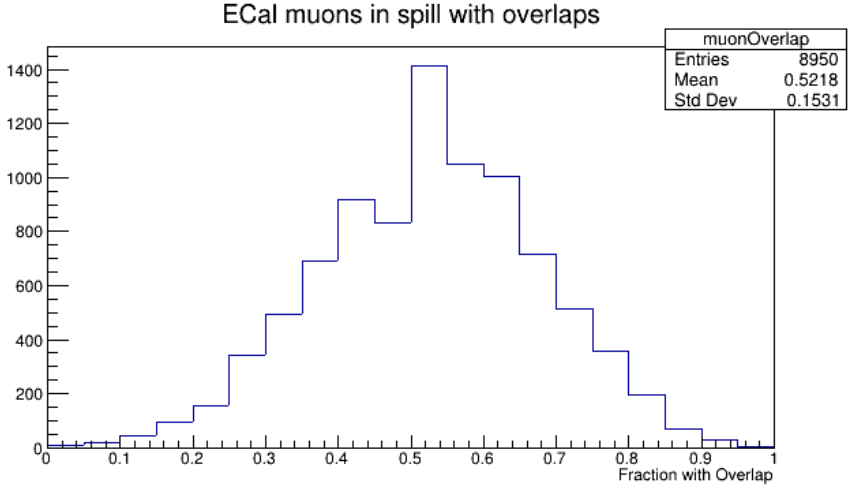
Overlap calculations

- A hit is considered to have overlap if (at least one must be true)
  - Collects energy from two or more separate neutrino interactions
  - Collects energy from two or more separate particles if
    - Particles are separated by 50 cm long cell axis
    - Or, particles are separated by more than 20 ns in time.
- Fraction of overlapping hits
  - The number of hits with overlaps divided by the total number of ECal hits
- Fraction of muons with overlaps
  - Check each hit for a muon to see if it has an overlap (from any source)
  - Number of muons with an overlapping hit divided by total number of muons.
- The ECal hit simulation does not track which particles contribute to which hits.
  - Some hits don't have nearby trajectories, some trajectories don't make hits. This introduces uncertainty in this study

RHC overlaps with a 400 ns integration

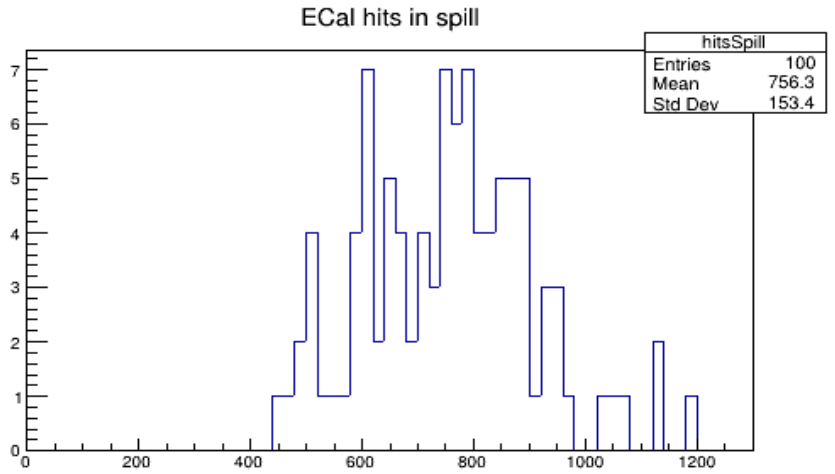
- This is the integration that is currentl implemented in sand-stt
  - Simulated using a constant fraction discriminator
- Hits: 625 per spill
  - Overlaps: 26.7%
    - about 790 w/o considering overlaps
  - A new simulation has 25% fewer hits.
    - Something changed. What?
- Muons with overlaps
  - An overlap will distort both the hit time and hit charge
  - Total overlaps: 52%
  - Upstream overlaps: 38%
    - Only consider overlap it it is on the upstream side of the detector

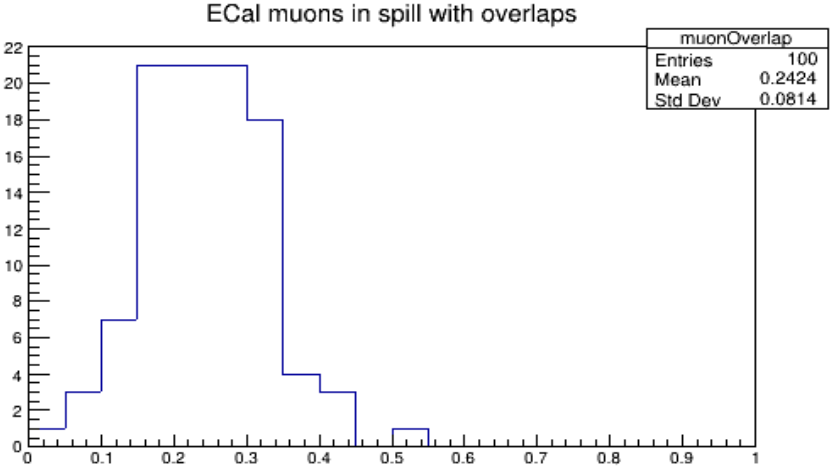




FHC overlaps with a 400 ns integration (very preliminary)

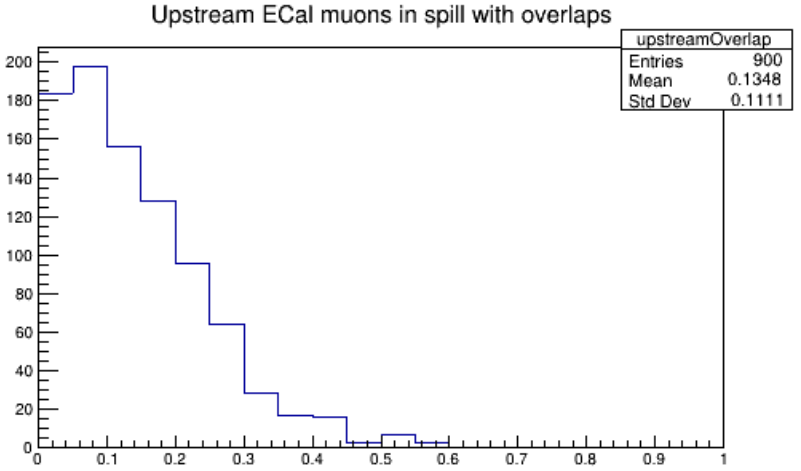
- This is the integration that is currentl implemented in sand-stt
  - Truth matching is approximate
- Hits: 756 per spill
  - Overlaps: 28%
- Muons with overlaps
  - Strongly affected by hit thresholds, which are not well simulated
  - Total overlaps: 24%
  - Upstream overlaps: 17%
    - Only consider overlap it it is on the upstream side of the detector

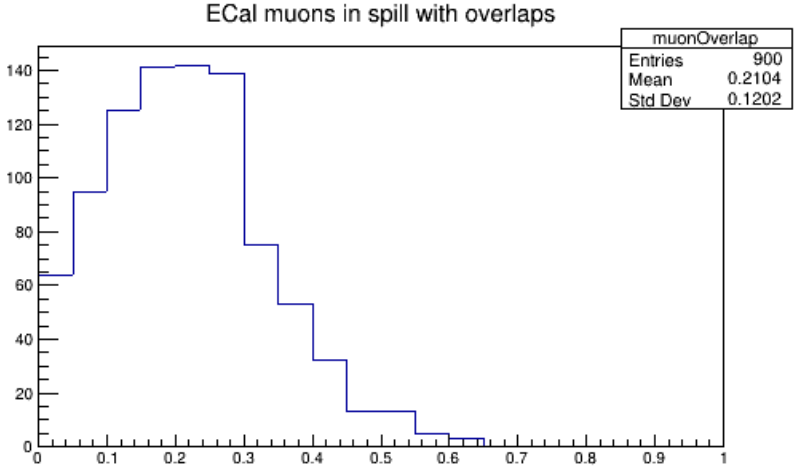




RHC overlaps with 30 ns integration

- Approximated by shortening integration window in sand-stt
- Current simulation is not self consistent for short windows
  - PMT pulses are long compared to 30 ns
  - 30 ns is short compared to the light transit time in fibers.
  - If sensor replaced, light yield will be different
- Simulation results
  - Hits: 4% overlap
  - Muons: 21% overlap (13% upstream)
    - This may be affected by threshold issues (possible overestimate?) and truth matching





End Notes

- This is preliminary, and I don't fully understand the ECal hit simulations
  - More study is needed to show ECal can be used as a beam monitoring target
  - Looking forward to definitive event selection studies from the ECal group
- There is a lot of activity expected in the ECal due to external interactions
  - 36 (52) interactions per RHC (FHC) spill will deposit energy
  - 1490 (2166) particles per RHC (FHC) spill (mostly low energy)
    - 140 (148) particles creating clusters of 3 or more hits.
  - Close to 800 (970) hits per RHC (FHC) spill (not accounting for overlaps)
  - 19 (30) muons per RHC (FHC) spill hit the ECal
    - 15 (23) muons per RHC (FHC) spill in upstream part of ECal
  - about 2 or 3 interactions per spill will originate from upstream part of ecal.
- Activity in the T2K barrel ECal has proven problematic
  - Roughly 4x granularity of KLOE ECal
  - Lower intensity beam
- ECal as a target for TPC and 3DST
  - Need carefully evaluation external backgrounds and fiducial volume efficiency for full spills
    - 400 ns integration: likely problematic for both RHC, and FHC.
    - 30 ns integration: probably significant overlaps for both RHC and FHC.

Backup Slides